A Quadrupole Ion Trap for the Detection of Biomarkers at Icy Worlds

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A quadrupole ion trap (QIT) mass spectrometer (MS) has been designed and built for the detection of biomarkers on icy worlds. The presence of icy plumes in the solar system like those found at Saturn's moon, Enceladus, has sparked interest due to their potential to contain signs of life. In the case of Enceladus, a subsurface ocean is responsible for feeding cryovolcanoes, which eject small ice particles several kilometers away from the surface of the moon's icy shell. Cassini demonstrated how a spacecraft travelling several km/s can easily sample these plumes and obtain mass spectra during a flyby. However, Cassini's instruments did not have the ability to identify potential biomarkers. We have made modifications to the Spacecraft Atmosphere Monitor (SAM) QIT-MS, making it possible to sample ice grains at hypervelocities and detect the biomarkers they contain.

A notch was cut into one of the end caps of the QIT-MS to allow ice grains to enter the trapping region and impact the ring electrode. Upon collision of an ice particle with the ring electrode at hypervelocities, its constituents will be volatilized and/or ionized. In the lab, volatilization of aqueous biomarker solutions inside the QIT-MS was achieved by flowing solutions of fatty and/or amino acids directly through an end cap and to the heated ring electrode. Volatized material was then ionized via chemical ionization (CI). Water was used in combination with other CI gases in order to find a suitable CI gas mixture capable of softly ionizing various fatty and amino acids. The use of water vapor as a collision gas for tandem MS was also demonstrated. Future plans of coupling the modified QIT-MS to a hypervelocity ice gun to better simulate ice plume sampling during a spacecraft flyby will also be discussed.